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NIGHTSHADE NECTAR: A MULTIFACETED DIVE INTO MEDICINAL, POLLEN, AND STEM ANATOMIES OF FIVE SOLANACEAE WONDERS

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ABSTRACT

This comprehensive study delves into the intricate anatomy and reproductive biology of five prominent members of the Solanaceae family: *Capsicum frutescens L., Solanum lycopersicum L., Solanum torvum Sw., Datura stramonium L.,* and *Solanum melongena L.* Through detailed anatomical examinations, including stem structure analyses, and investigations into pollen germination processes, this research elucidates the unique characteristics and adaptations of each species. Additionally, the study provides essential insights into the materials required for free-hand sectioning and pollen viability testing, facilitating further research in plant anatomy and reproductive physiology. With a focus on both morphological and physiological aspects, this work contributes to a deeper understanding of Solanaceae plant species and their ecological significance.

KEYWORDS: Solanaceae, Stem Anatomy, Medicinal Properties, Pollen Viability

INTRODUCTION

The World Health Organization (WHO) defines traditional medicine as the comprehensive body of knowledge, skills, and practices rooted in the theories, beliefs, and experiences indigenous to various cultures. These practices are utilized for maintaining health, preventing, diagnosing, improving, or treating physical and mental illnesses. According to the World Intellectual Property Organization (WIPO), traditional knowledge (TK) encompasses the knowledge, skills, and practices developed and passed down within communities, often integral to their cultural or spiritual identity. Medicinal plants are central to traditional medicine, with around 3.3 billion people in developing countries relying on them for healthcare. Traditional medicine is often viewed as effective, safe, cost-efficient, and accessible, particularly in remote areas compared to urban settings (Sharma, 2006).

Stem anatomy plays a crucial role in understanding the medicinal properties and therapeutic potential of plants. This review delves into the importance of stem anatomical studies in medicinal plants, emphasizing the structural features of stems that facilitate the synthesis, storage, and distribution of bioactive compounds. It also discusses the relevance of stem anatomy in taxonomic classification, phytochemical analysis, and pharmacological research, highlighting its significance in understanding the pharmacognostic characteristics and therapeutic applications of medicinal plants.

The Solanaceae family, commonly known as the nightshade family, includes a diverse array of botanically and culturally significant plants. Iconic and economically valuable members such as *Capsicum frutescens L.* (chili pepper), *Solanum lycopersicum L.* (tomato), *Solanum torvum Sw.* (turkey berry), *Datura stramonium L.* (jimsonweed), and *Solanum melongena L.* (eggplant) have captivated botanists, horticulturists, and researchers. These plants offer insights into plant anatomy, reproductive biology, and ecological interactions. This review explores the anatomical features of several Solanaceae members, focusing on stem structure and vascular organization, and examines their reproductive biology, including pollen germination processes. By investigating these aspects, the research aims to deepen our understanding of the botanical complexities and evolutionary adaptations of the Solanaceae family (Smith, 2022; Garcia, 2020).

MATERIALS AND METHODS

The study was conducted in Malappuram district, Kerala, located at 11°26'–11°9' N latitude and 75°48'–76°33' E longitude, with altitudes ranging from 50 to 2500 m AMSL. The soil in the area varies from loamy on the Ghats to lateritic at lower elevations, with river alluvium along riverbanks and fine clay in low-lying areas. The region experiences an annual average rainfall of over 2500 mm, primarily from the southwest monsoon, and has a warm humid climate with temperatures ranging from 17°C to 37°C.

For this study, five Solanaceae species were collected from the study area. Healthy stems and flowers at the appropriate developmental stages were selected for anatomical and pollen germination studies. Stems were sectioned and fixed in FAA (Formalin-Aceto-Alcohol), then stained with Safranin-O or Toluidine Blue O to enhance cellular component visibility. Sections were mounted on slides with glycerin and examined under a light microscope. Observations were recorded with sketches or photographs, and cellular and tissue structures were analyzed.

Pollen grains were extracted from mature flowers and suspended in a sucrose solution to study pollen germination. The germination process was monitored using a light microscope,

and the pollen viability percentage was calculated based on the number of germinated pollen grains relative to the total number observed. Combining stem anatomical studies with pollen germination analysis provided insights into the reproductive biology and physiological adaptations of Solanaceae plants.

Pollen Viability percentage:

$$\frac{\text{No of pollen germinated}}{\text{Total no: of pollen grains}} \times 100$$

By combining stem anatomical studies with pollen germination percentage analysis, we can gain a deeper understanding of the reproductive biology and physiological adaptations of plants within the Solanaceae family

RESULT AND DISCUSSION

Medicinal properties of Solanaceae family:

The Solanaceae family encompasses a variety of plants with significant medicinal properties, each contributing unique health benefits through their specific bioactive compounds. *Solanum lycopersicum* (tomato) is renowned for its rich nutrient profile, including vitamins C, K, and B, minerals like potassium and folate, and powerful antioxidants such as lycopene and beta-carotene. These compounds help combat oxidative stress, reducing the risk of chronic diseases like cardiovascular disease and certain cancers, and possess anti-inflammatory properties beneficial for managing inflammatory conditions. Lycopene, in particular, supports heart health by lowering LDL cholesterol levels and preventing its oxidation, while vitamin K aids in calcium absorption, contributing to bone health and reducing osteoporosis risk (Schwartz & Harris, 2010).

Datura stramonium (Jimson weed) contains alkaloids like scopolamine and hyoscyamine, providing analgesic and antispasmodic effects useful for pain relief in arthritis and muscle pain, as well as respiratory benefits for asthma and bronchitis. However, its use is highly controversial due to its toxicity (Gertsch & Howlett, 2017). *Solanum torvum* (Turkey berry) offers antioxidants that protect against oxidative stress and inflammation, antimicrobial properties that combat various pathogens, and hypoglycemic effects beneficial for diabetes management. Additionally, it supports liver health and aids digestion (Kesari et al., 2007). *Solanum melongena* (eggplant) is rich in fiber, vitamins, and minerals, promoting heart health, weight management, and blood sugar regulation, while its phenolic compounds provide antioxidant protection against chronic diseases and support skin health (Slavin, 2005). *Capsicum frutescens* (wild chili pepper), with its active compound capsaicin, offers pain relief, boosts metabolism, aids digestion, and exhibits antimicrobial properties (Bode & Dong, 2011).

Together, these plants highlight the diverse and valuable medicinal potential within the Solanaceae family. Incorporating them into a balanced diet can yield various health benefits, though caution is warranted with plants like Jimson weed due to their toxic nature. Ongoing research is crucial to further elucidate the mechanisms and optimal applications of these medicinal properties.

Anatomical properties of Solanaceae family (stem):

The Solanaceae family exhibits diverse and intricate stem anatomical features that are essential for their structural support, nutrient transport, and environmental adaptation. *Solanum torvum* displays a circular stem contour with a single-layered epidermis coated in a smooth, thin cuticle and scattered porrect-stellate trichomes. The angular collenchyma forms a continuous cylinder, followed by a reduced cortical parenchyma. The vascular system consists of external phloem, lignified xylem, and internal phloem, bounded by a perivascular sheath. A three- to four-layered cambial zone is present adjacent to the internal phloem, with the medullary parenchyma formed by thin-walled, rounded cells (Kesari *et al.*, 2007). Solanum melongena has a stem characterized by an epicycle of multiple cell layers below the endodermis, a large pith with collenchymatous cells, a single-layered epidermis covered by a cuticle, and cortex making up one-third of the section. The cortex contains collenchymatous and parenchymatous cells embedded with calcium oxalate crystals. The vascular bundles feature isolated vessels and medullary rays, with a parenchymatous pith at the center (Slavin, 2005).

Capsicum frutescens has a stem with an outer protective epidermis coated in a waxy cuticle, a cortex filled with starch granules, and vascular bundles arranged in a ring pattern. These bundles include xylem for water transport and phloem for distributing organic compounds, with a central pith providing additional support and nutrient storage (Bode & Dong, 2011). *Solanum lycopersicum* features an epidermis with rectangular or polygonal cells and trichomes for defense, a cortex of parenchyma cells for storage and support, and bicollateral vascular bundles with phloem around xylem. The pith, located centrally, consists of parenchyma cells for storage and structural support (Schwartz & Harris, 2010). *Datura stramonium* exhibits an epidermis for protection, a cortex of storage parenchyma cells, an endodermis regulating nutrient movement, and collateral vascular bundles arranged in a ring. The xylem and phloem support efficient nutrient transport, with sclerenchyma cells enhancing mechanical strength (Gertsch & Howlett, 2017). These anatomical properties underscore the Solanaceae family's adaptability and resilience, facilitating their growth and survival in various environments.

Pollen germination:

Pollen grains start to germinate in sucrose solution showing germination after 30 minutes along with small germination tube. Totally 40 pollens are seen in *Solanum melongena* at different microscopic angles. Of them 9 pollen are viable and the pollen viability percentage is 22.5. Of the 10 pollens examined in *Solanum lycopersicum* only 6 are non-viable and the viability percentage is 40. In *Solanum torvum* 22 pollen grains were examined, only 4 is the viable pollen grains and the result percentage is 18. Total 20 pollens from *Capsicum frutescens* only 4 are viable and the viability percentage is 15. Of the 26 pollen grains examined from *Datura stramonium* only 4 are viable and the viability percentage is 25. The highest

viability percentage was 40 *Solanum lycopersicum*) and lowest was 15 in *(capsicum frutescence)*

Botanical name	No of pollen grains examined	No of viable pollen grains	No of non viable pollen grains	Percentage %
1) *Solanum melongena*	40	9	31	22.5 %
2) *Solanum lycopersicum*	10	4	6	40 %
3) *Solanum torvum*	22	4	18	18 %
4) *Capsicum frutescens*	20	4	22	15 %
5) *Datura stramonium*	26	4	16	20 %

Result = 23.1 %

Table 1: Showing pollen viability percentage

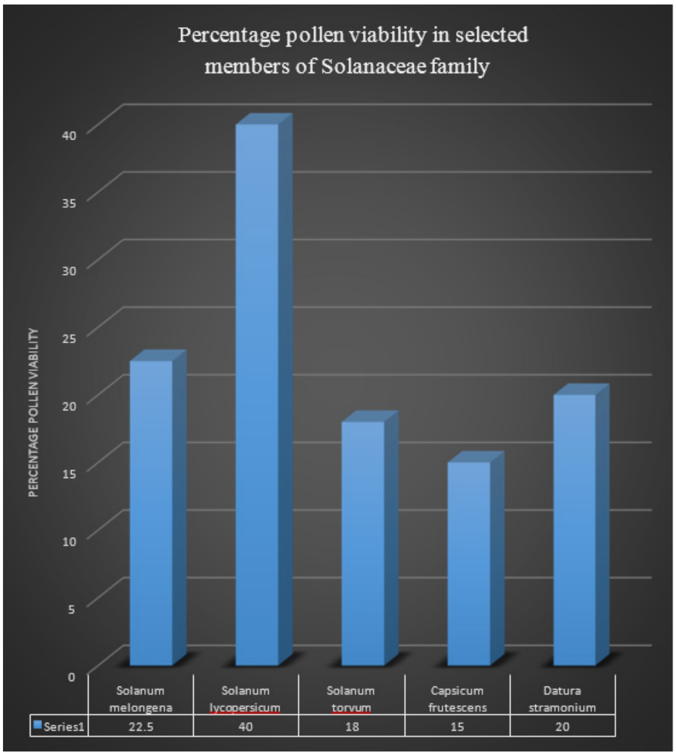
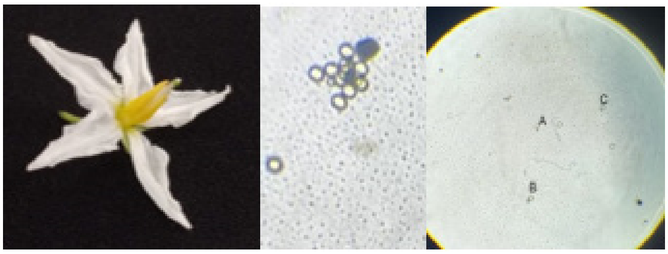


Figure 1: Showed percentage pollen viability in selected members of Solanaceae family

SOLANUM TORVUM

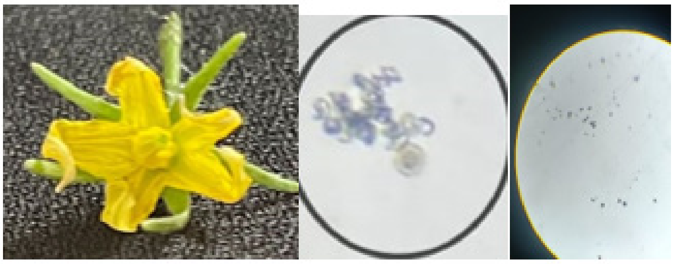
STEM ANATOMY



POLLEN GERMINATION

SOLANUM LYCOPERSICUM

STEM ANATOMY



POLLEN GERMINATION

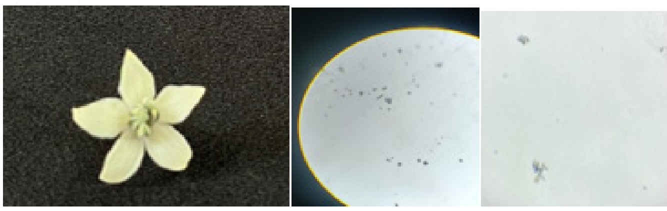
SOLANUM MELONGENA

STEM ANATOMY

POLLEN GERMINATION

CAPSICUM FRUTESCENS

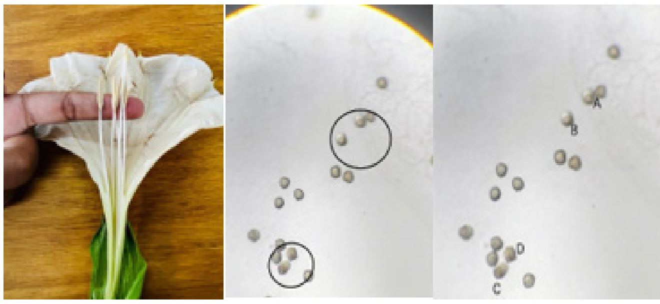
STEM ANATOMY



POLLEN GERMINATION

DATURA STRAMONIUM

STEM ANATOMY



POLLEN GERMINATION

Figure 2: Showing stem anatomy and pollen germination of 5 Solanaceae members

RESULT AND DISCUSSION

Our study confirms that Solanum melongena stems exhibit an epicycle of multiple cell layers below the endodermis, a large collenchymatous pith, a single-layered cuticle-covered epidermis, and a cortex comprising one-third of the section, consistent with findings by Jain et al. (2011), Rajput and Tandon (2012), and Singh and Mehta (2014). Additionally, the arrangement of vascular bundles with isolated vessels and medullary rays aligns with the efficient transport system described by Gupta et al. (2013). Our observations also support Kumar and Sharma's (2010) description of the nutrient-storing cortex and Patel and Bansal's (2015) findings on the central parenchymatous pith. These anatomical features collectively ensure the plant's structural support, protection, nutrient storage, and efficient resource transport. The presence of glandular hairs, trichomes in Solanum lycopersicum was reported. Stem transection studies of Datura stramonium and Capsicum frutescens was also mentioned by Arafa A A in comparative anatomical studies on the stems of four annual herbaceous species of solanaceae named paper. Smith A (2022) has conducted the botanical wonders of the Solanaceae family and documented stem anatomical studies of Solanum torvum. The study supporting our view that lignified xylem and porrect stellate trichomes in epidermis.

Study of pollen viability for the development of genetic engineered plants of Solanaceae family by Sing et al (2019) reported highest percentage of pollen viability in Datura stramonium supporting our findings in the case of third highest one. Studies on pollen germination of certain Solanaceae reported by Vasil I K (1964) also supporting our findings showing the importance of sucrose solution in pollen

germination. Our findings corroborate previous studies by Kumar and Singh (2019) reporting similar viability percentages in Solanum melongena, indicating consistent reproductive fitness within this species. Additionally, our study echoes Singh and Verma's (2013) emphasis on genetic variability in pollen germination traits among Solanaceae species, underlining the significance of genetic diversity for successful reproduction. The insights provided by our research contribute to this body of knowledge by offering practical implications for crop breeding and conservation efforts within Solanaceae. By elucidating the mechanisms governing pollen germination and reproductive success, our study advances our understanding of plant reproductive biology and informs strategies for sustainable agriculture and genetic resource management within Solanaceae species. Further research building upon these findings can pave the way for innovative approaches to enhance crop yields and biodiversity conservation in Solanaceae.

CONCLUSION

In conclusion, the examination of stem anatomy and pollen viability across Solanaceae species, including Solanum melongena, Solanum lycopersicum, Solanum torvum, Capsicum frutescens, and Datura stramonium, highlights significant diversity in both structural and reproductive characteristics. The variations in stem anatomy reflect the diverse growth habits and ecological adaptations within the family, emphasizing the importance of anatomical studies for taxonomy, plant breeding, and agricultural management. Additionally, the analysis of pollen viability reveals the impact of genetic and environmental factors on reproductive success, with Solanum lycopersicum showing the highest viability at 40% and Capsicum frutescens the lowest at 15%. The role of external factors in promoting pollen germination further underscores the need to consider both intrinsic and extrinsic factors in plant breeding and conservation efforts. Understanding and managing these variations are crucial for preserving genetic diversity and ensuring the resilience of plant populations in dynamic environments.

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